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RICE EXPERIMENTS IN SACRAMENTO VALLEY 1922-1927

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Experimental field at Cortena just after submergence

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RICE EXPERIMENTS IN SACRAMENTO VALLEY
1922-1927

CARROLL F. DUNSHEE[1]

This bulletin[2] presents a progress report of rice experiments carried on by the Division of Irrigation Investigations and Practice, University of California, at the temporary rice field station near Cortena since 1922; also, a summary of measurements of the duty of water in rice irrigation in 1924 and 1925. Detailed reports of the results obtained at Cortena during 1922 and 1923 appeared as bulletins 354 and 375 of the University of California Agricultural Experiment Station.

The experiments at Cortena were started in 1922, following requests from the rice growers for information on methods of weed control. At that time the growers were especially concerned over the control of the barnyard grass or water grass (*Echinochloa crus-galli*). There was no satisfactory method generally practiced for the control of this weed, although a few growers were obtaining fairly good results from submerging the rice at time of planting. For this reason the experiments outlined covered a series of cultural and depth-of-submergence tests to determine the most satisfactory method of controlling the water grass, as well as other weeds prevalent in the rice fields. In addition to these experiments, a study was started to determine the best date of seeding and the effect of fallow on the yield of rice.

The land at Cortena was first planted to rice in 1918 and farmed each year through 1921, at which time it was abandoned by the lessees because of the presence of water grass, cat-tails (*Typha latifolia*), and other rice weeds. This area was selected for the experimental work because it was particularly foul and situated on Willows clay adobe soil, which is representative of a large area devoted to rice culture on the west side of the Sacramento Valley.

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[1] Assistant Crop Irrigationist, Division of Irrigation Investigations and Practice.

[2] Based on data gathered in part in cooperation with the Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture; and in part in cooperation with the Division of Agricultural Engineering, U. S. Department of Agriculture, and the Division of Water Rights, California Department of Public Works.

Responsibility for the rice investigations referred to in this bulletin lies with the Division of Irrigation Investigations and Practice, but that Dvision has the advantage of the advice, in planning the investigations from year to year, of the following Rice Committee appointed by the Director of the Experiment Station: Frank Adams, Chairman; P. L. Hibbard, J. W. Jones (Superintendent of the Biggs Rice Field Station of the Bureau of Plant Industry), P. B. Kennedy, W. W. Mackie, C. F. Shaw, W. W. Weir, and E. J. Stirniman.

The series of experiments outlined to determine the best method of weed control, while still producing satisfactory yields, were as follows:

1. Broadcasting 150 pounds of seed per acre on well prepared seed bed, and submerging immediately to depths of 4, 6, and 8 inches, continuing the submergence throughout the season.
2. Drilling seed at the rate of 150 pounds per acre and submerging immediately to depths of 4, 6, and 8 inches, continuing submergence throughout the season.
3. Drilling seed at the rate of 150 pounds per acre and submerging to depths of 4, 6, and 8 inches after the rice had sprouted and was about 1 inch high.
4. Broadcasting 150 pounds of seed per acre in water held at depths of 4, 6, and 8 inches.
5. Effect of seed bed preparation on the control of weeds and the yield of rice. In this series the land was not plowed, the seed being sown broadcast at the rate of 150 pounds per acre on the old rice stubble.

Supplementing the above studies a series of experiments were conducted to determine the proper time of seeding.

METHOD OF SEEDING

The results of the work at Cortena, and at the Biggs Rice Field Station conducted by the United States Bureau of Plant Industry, where similar studies were under way,[3] showed conclusively that of the four irrigation and seeding treatments tried, that of broadcasting and submerging the seed to depths of six to eight inches held the most promise. A summary of the results obtained at Cortena is given in table 1.

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[3] Jones, Jenkin W., Experiments in rice culture at the Biggs Rice Field Station in California. U. S. D. A. Dept. Bul. **1387**: 1–39. 1926.

TABLE 1

Summary of Results at Cortena Showing Effects of Methods of Seeding and Depths of Submergence on Weed Control and Yields of Rice, 1922–1924

Depth of submergence in inches	Weed control	Yields in pounds of rice per acre for various methods of seeding			
		Drilling		Broadcasting	
		Seed sprouted before submerging	Seed submerged immediately	Seed submerged immediately	Seeded in water
4	Part control	1,212	1,167	2,149	2,271
6	Clean	1,606	1,062	2,812	1,812
8	Clean	1,958	1,782	2,813	2,247

DATE OF SEEDING

The results from the first experiments conducted to determine the best date of seeding indicated very clearly that the highest yields could be expected from the earliest date of seeding. It was, therefore, the aim in succeeding tests to seed first on April 15, but due to late spring rains it has been possible to do this only one year. Rice planted on June 1 was a week or ten days later in maturing than that of the earlier seeding. There were many more immature kernels on the panicles than on that seeded earlier. The results are shown in table 2.

TABLE 2

Results at Cortena on Date of Seeding, 1922–1923

Date	Method of seeding	Yields of rice in pounds per acre		
		1922	1923	Average
April 25*	Broadcast and immediate 6-inch submergence	3,664	2,788	3,226
May 1		2,558	2,338	2,448
May 15		2,648	2,388	2,518
June 1		2,069	1,137	1,603

* April 15 in 1922.

EFFECT OF SEED BED PREPARATION ON WEED CONTROL

The experiments on the effect of plowing on weed control show definitely that it is necessary to plow deep enough to turn the cat-tail roots up to the sun during the period of seed bed preparation. In the plots which were plowed each year, the cat-tail growth was satisfactorily controlled, and indeed, there have been fewer cat-tail plants appearing each succeeding year. Such cat-tail plants as have appeared have been pulled during July. The cost of pulling has not averaged more than seventy-five cents an acre per year during the period the experiments have been under way. Four plots having a total area of three acres were not plowed, the seed being broadcast on the rice stubble at the rate of 150 pounds per acre, and submerged immediately to a depth of six inches. The growth of cat-tail, joint grass (*Paspalum distichum*) and spike rush (*Eleocharis palustris*) became very thick, resulting in low yields. In 1922 the average yield amounted to 1368 pounds per acre, while in 1923 this area was so foul at harvest time that it was impossible to cut the rice. The area was again planted to rice in 1924, and because of the dense weed growth the rice was bound with considerable difficulty in the fall. The yield that year averaged 632 pounds per acre. During 1925 and 1926 these plots were plowed each spring and fallowed. They were again plowed in the spring of 1927 and seeded to rice at the rate of 150 pounds per acre. The control of the cat-tail and other weeds was very satisfactory, the cost of pulling those plants which did grow amounting to $1.65 an acre. The yields obtained were excellent, averaging 4460 pounds to the acre.

EXPERIMENTS UNDER WAY SINCE 1924

Following the season of 1924 a cooperative agreement relating to rice investigations was made between the Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the California Agricultural Experiment Station. It was decided at that time to conduct the main experimental work with rice at the Biggs Station, and use the Cortena Station to study the effect of continuous rice growing on the yield of rice, the control of weeds, and on the physical, chemical, and biological condition of the soil. It was also decided to test out at Cortena certain of the methods tried at Biggs which appeared to be of practical value; among these being the use of ammonium sulphate as a rice fertilizer. With this in view the entire area at Cortena has been managed according to the best practice determined during the years 1922 to 1924. Each year a fine seed bed has been prepared, the seed broadcasted on the surface at the rate of 150 pounds per acre, and the whole area submerged immediately to depths varying between six and eight inches. It has been the practice to seed as early in the spring as possible, but the date has been delayed at times until May 15, due to late rains. The frontispiece shows a view of a portion of the experimental area just after submergence.

The north half of the field was fallowed in 1924, but was rechecked and planted to rice again in 1925. It was noticeable during the course of seed bed preparation that this area was in considerably better physical condition than before the year of fallow. Where there had been a few cat-tail plants on this area during the two preceding years, none appeared during the 1925 season. There was a slight increase in yield in this area over the yield received from the south half of the field during 1925 and 1926. It is probable that this increase may be attributed to the beneficial effects of the fallow. However, in 1927 the average yield from the south field was considerably more than the average yield from the field fallowed in 1924.

USE OF AMMONIUM SULPHATE AS A RICE FERTILIZER

The results from the use of ammonium sulphate at Cortena have shown an increase in the yield of rice in favor of the fertilized plots each year. During 1925 and 1926 the fertilizer was applied at the rate of 100 pounds per acre with the result that the average increase in yield over the unfertilized area was approximately 800 pounds per acre in 1925 and approximately 500 pounds per acre in 1926. Due to the results obtained at the Biggs Station over a period of years, which indicated that 150 pounds per acre was the most economical rate of application, the rate at Cortena was increased to 150 pounds per acre in 1927. That year the increase in yield in favor of the fertilized plots was approximately 1200 pounds per acre. Inasmuch as the cost of the fertilizer, plus application, has never amounted to more than $5.50 per acre, the use of this fertilizer appears to be an economical procedure.

The results obtained from the use of ammonium sulphate since 1924 are summarized in table 3.

TABLE 3

RESULTS OBTAINED FROM FERTILIZING RICE FIELDS WITH AMMONIUM SULPHATE, AT CORTENA, 1925–1927

Year	Date of seeding	Treatment	Area, acres	Yield per acre
1925	May 15	Unfertilized	18.57	2,797
		Fertilized	3.10	3,585*
1926	May 10	Unfertilized	18.43	2,343
		Fertilized	3.10	2,846*
1927	May 1	Unfertilized	20.03	3,288
		Fertilized	3.10	4,486†

* Fertilized at the rate of 100 pounds to the acre.

† Fertilized at the rate of 150 pounds to the acre.

WEED CONTROL BY CONTINUOUS SUBMERGENCE[4]

Summarizing the observations on weed control, the studies at Cortena show that continuous submergence to depths of 6 to 8 inches after the rice is sown broadcast will satisfactorily control most of the various types of water grass and will result in good yields. This method will also control the sprangle top (*Leptochloa fascicularis*). However, continuous submergence will not control the late white water grass, which matures its seed in September and October. The only method of control known is to pull these weeds as they appear in the field. If the white water grass is not controlled it will result in reduced yields, and also in a lower grade of rice, unless it is recleaned before being placed on the market. Figure 1 indicates the extent of control of water grass when the continuous submergence method is practiced.

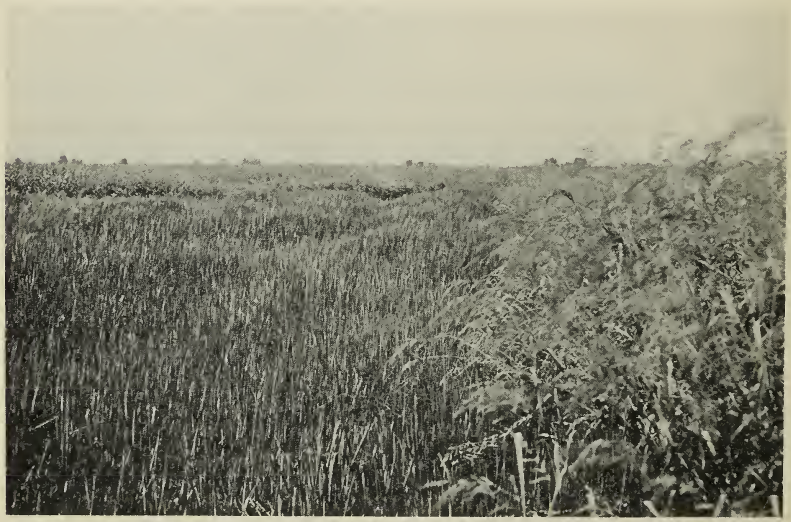

Fig. 1.—Rice grown under continuous submergence method. Note absence of water grass between levees in left foreground. (From Bul. 354.)

Sedge (*Cyperus difformis*), red stem (*Ammania coccinea*), arrowhead (*Sagittaria latifolia*), and the water plantain (*Alisma plantago*) can usually be satisfactorily controlled with a thick stand of rice which has been planted as early in the spring as possible. In order to insure a thick stand of rice at least 150 pounds of well matured seed should be sown on a smooth seed bed.

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[4] A discussion of the rice weeds of California has appeared in: Kennedy, P. B., Observations on some rice weeds in California. California Agr. Exp. Sta. Bul. 356: 467–494. 1928.

The cat-tail (*Typha latifolia*) can be satisfactorily controlled, providing the soil is well plowed each spring and the roots are allowed to dry four or five days before preparing the seed-bed. This must be followed by pulling the plants which do grow. It appears that the best time to pull cat-tails is during the month of July. This is sufficiently late to be sure that few plants will appear later in the season, and early enough so that the rice will not be damaged by tramping on it while it is in the boot. Where fields have become foul due to poor farming it may be necessary to fallow the land for one or two years before the cat-tail growth can be satisfactorily controlled.

Joint grass (*Paspalum distichum*) can be controlled by fallow for a year or two after the fields become so foul with this weed that the further production of rice is not economical. The weed usually starts from the levees and after a few years the runners may be found fifty or seventy-five feet out in the rice field.

Wire grass or spike rush (*Eleocharis palustris*) can be satisfactorily controlled by a thorough plowing in the spring. If the roots of this weed are turned up to the sun to dry for four or five days, very few of the plants will survive. It is usually only in the corners of the field that this weed is at all troublesome.

COMPARISON OF AIR AND WATER TEMPERATURES

It is believed by some growers that during periods of cool weather the soil can be warmed by withdrawing the irrigation water for a few days. In order to make a comparison of the air and water temperatures during the growing season, a thermograph record of the water temperatures was kept, beginning in 1924. An air thermograph was installed at the time the station was started. The torpedo of the thermograph recording the water temperatures was placed on the soil surface under six inches of water and was some eight feet out in the rice check, the recording machine being placed on the levee. The air thermograph was placed in a Standard Weather Bureau shelter house. The records of these two instruments show that during May the average maximum water temperature was always as high, and at times higher, than the average maximum air temperature. The average minimum water temperature was always higher than the average minimum air temperature. However, as the rice grows taller and shades the water, the maximum temperature of the water falls below the maximum air temperature.

DUTY OF WATER IN RICE IRRIGATION

During the irrigation seasons of 1924 and 1925 studies were carried on to determine the use of water in rice irrigation under the practice of all-season submergence. Previous to those years studies had been conducted on the use of water under the method of ''flushing'' the field from four to six times prior to permanent submergence.[5] They show a net use varying from 3.94 acre-feet to the acre on what are known in the soil surveys as Capay clay soils, to 10.94 acre-feet to the acre on the San Joaquin loam soils. On the clay, clay adobe, and adobe soils, which are the usual rice soils in the Sacramento Valley, the net use varied between 3.94 and 5.72 acre-feet per acre.

Since the method of continuous submergence from time of planting was becoming a general practice on old land, the studies conducted in 1924 and 1925 were intended to determine the difference in water requirement, if any, due to all-season submergence. Theoretically, providing the length of the irrigation season is the same, continuous submergence should result in a larger use than submergence beginning several weeks after seeding. The longer period of submergence should result in greater loss through seepage, evaporation, and waste over the tail gate. However, the results obtained during 1924 and 1925 showed practically the same use as obtained with the earlier method. This may be due to the fact that earlier maturing varieties are now being planted, and the method of continuous submergence further hastens the maturity of rice by several days. In 1916, 1917 and 1918 the length of the irrigation season varied from 139 to 189 days, with the irrigation season on the majority of the fields, more than 155 days. In 1924 and 1925 the length of the irrigation season varied from 109 to 146 days, with only two fields exceeding 140 days.

Six fields were studied in 1924, the total area being 1200.49 acres. The individual fields varied in size from 63 to 612.9 acres. These fields were located on the west side of the Sacramento Valley, from Williams north to Willows, and covered the range of soil types on which rice is most generally grown in this area. Measurements of delivery to the fields were made with submerged orifices, carefully standardized, while the drainage water was measured over rectangular weirs. Automatic water-stage registers, visited daily throughout the season, recorded the flow in both cases. Typical installations of these devices are shown by figures 2 and 3. In all, 27 water-stage registers were necessary. At the close of the season, yields produced on all fields under observation were obtained and are included in the tables given below. However, yields are influenced so much by the human factor and the elements that they can not be directly correlated with amounts of water used. The results of the 1924 season show a net use ranging from 4.20 acre-feet per acre on the Willows clay adobe soils

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[5] Adams, Frank. Rice irrigation measurements and experiments in Sacramento Valley, 1914–1919. California Agr. Exp. Sta. Bul. **325**: 47–69. 1920.

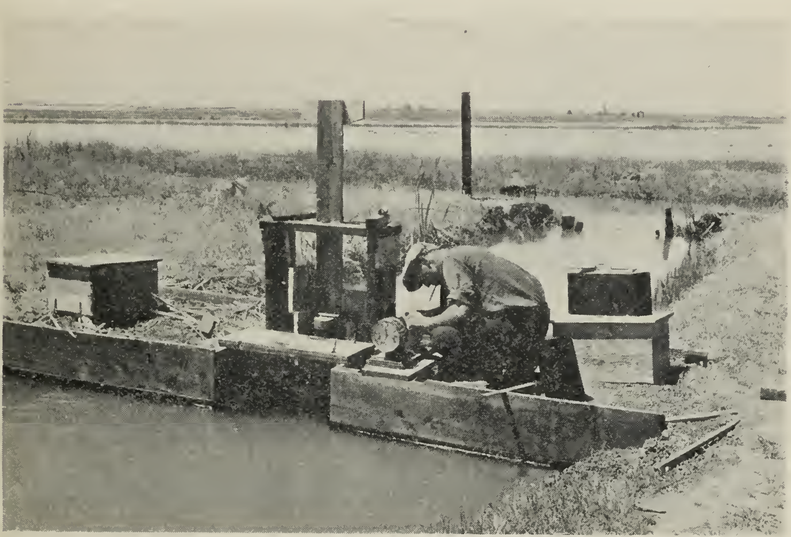

Fig. 2.—Typical submerged orifice used in measuring delivery of water to rice fields, 1924.

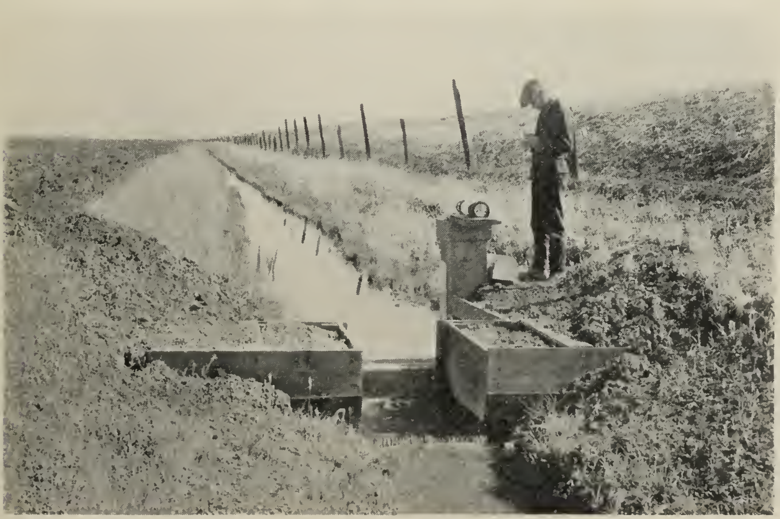

Fig. 3.—Typical rectangular weir used in measuring drainage water from rice fields, 1924.

to a net use of 7.41 acre-feet per acre on the Willows loam soils. The average net use on the Willows clay and clay adobe amounted to 4.81 acre-feet to the acre.

Two fields were studied in 1925, one field of 112 acres being located near Cortena on Willows clay soil, and the other field, comprising 38.8 acres, was on Stockton clay adobe soil adjacent to the Biggs Rice Field Station. The same procedure followed in 1924 was continued during 1925.

The Armstrong field at Biggs was formerly farmed by Mr. E. L. Adams and measurements of use of water were made on this field from 1914 to 1917, inclusive, under the old method of flushing several times before submerging the field permanently. It is interesting to note that the net use on this field in 1916 was 4.27 acre-feet to the acre, and in 1917 the net use was 4.37 acre-feet to the acre, the average use for the four seasons having been 4.53 acre-feet to the acre. In 1925, under the continuous submergence method, the net use amounted to 4.88 acre-feet to the acre. This increased use may be due to the fact that since 1918 deep drains have been constructed on two sides of the field. The irrigation season in 1916 amounted to 171 days and in 1917 to 164 days, while in 1925 the length of the irrigation season was 134 days.

The results of the work in 1925 show that on the Willows clay adobe the net use was 4.27 acre-feet to the acre, while on the Stockton clay adobe the net use was 4.88 acre-feet to the acre.

In tables 4 and 5 are included summaries of the data obtained on the use of water during 1924 and 1925.

TABLE 4

DUTY OF WATER FOR RICE ON EIGHT FIELDS UNDER ALL-SEASON SUBMERGENCE, 1924–1925

Year	Grower	Acreage	Total intake, acre-feet	Total measured drainage, acre-feet	Total lost over levees, acre-feet (estimated)	Acre-feet on field at date of draining (estimated)	Variety of rice	Yield, pounds per acre
1924	Husted	63.28	492.00	129.91	None	21.09	Onsen	2,978
1924	Yarborough	102.38	532.21	92.71	9.30	34.12	Caloro	2,780
1924	Rathbun	111.67	789.93	212.70	None	27.91	Onsen	2,770
1924	Bruggman	109.41	734.19	163.69	64.87	27.35	Caloro	2,496
1924	Goepf	200.85	1,653.48	63.53	None	100.43	Caloro	2,275
1924	Jones	612.90	5,109.08	587.67	None	204.30	Early Wataribune	1,028*
1925	Anderson	112.05	651.25	119.30	None	56.0	1,600	2,699
1925	Armstrong	38.8	318.83	129.40	None	Drainage all measured	Caloro	3,200

* Based on area irrigated; 1,139 pounds, based on area harvested.

TABLE 5

Summary of Measurements of Duty of Water for Rice, 1924–1925

Year	Owner	Grower	Soil classification from soil maps of U. S. D. A., Bureau of Soils	Area, acres	Irrigation season, days	Depth of water applied, acre-feet			Area served per cubic foot per second, based on net use				Acres served per cubic foot per second based on total intake, less measured drainage and less acre-feet of water on field on date of draining	
						Total	Net	Average net for soil type	During submergence, acres	From submergence to end of season, acres	For whole season, acres	Average whole season for soil type, acres	Individual fields	Average for soil type
1924	Moore	Husted	Willows clay	63.28	125	7.78	5.72	4.96	12.65	47.22	43.35	55.81	46.18	60.45
1924	Yarborough	Yarborough	Willows clay	102.38	146	5.19	4.20	....	24.90	78.15	68.57	....	74.73	... .
1924	Hotaling	Rathbun Bros.	Willows clay adobe	111.67	109	7.06	5.03	4.66	27.33	48.55	42.79	52.80	45.21	55.09
1924	S.V.S.F.L.Co.	Bruggman	Willows clay adobe	109.41	137	6.67	4.67	....	34.51	67.45	57.88	....	62.52	....
1924	Minor Ranch	Goepf	Willows loam	200.85	143	8.23	7.41	....	30.67	36.72	35.89	....	38.18	....
1924	Barcelaux	Jones	Willows loam and Willows clay adobe	612.90	133	8.34	7.09	....	35.53	35.74	35.69	....	37.39	....
1925	Esperanza Land Co.	Anderson and Bank of Williams	Willows clay adobe	112.05	124	5.81	4.27* 4.77†	....	19.44	56.87	51.63	....	57.73	....
1925	Armstrong	Armstrong	Stockton clay adobe	38.8	134	8.21	4.88‡	....	7.87	58.79	53.29‡	....	53.29‡	....

* Based on total measured intake less total measured drainage, less estimate of 56 acre-feet left on field at end of season and not measured.

† Net as shown on register sheets.

‡ Drainage all measured.

SUMMARY AND CONCLUSIONS

1. Rice sown broadcast at the rate of 150 pounds per acre and immediately submerged six to eight inches deep will produce satisfactory yields on old land, providing well matured seed is used and planted as early in the spring as possible on a well prepared seed bed.

2. The continuous submergence of rice to depths of six to eight inches will control sprangle top and the earlier maturing types of water grass.

3. Continuous submergence will not control the late white water grass. This weed should always be pulled where it is economically possible to do so.

4. Deep plowing in the spring will aid in the control of cat-tail plants, provided the up-turned roots are allowed to become thoroughly dry before preparing the seed bed. Any of these plants that are not killed by this treatment should be pulled during July.

5. The detrimental effects of such weeds as sedge, red stem, arrowhead and water plantain are materially reduced by thick stands of rice.

6. Joint grass can usually be controlled by a year or two of dry fallow.

7. Spike rush can be satisfactorily controlled by a thorough spring plowing, provided a period of drying weather follows.

8. On old land which is not producing more than 3000 pounds to the acre it is an economical practice to apply 150 pounds of ammonium sulphate to the acre just prior to seeding.

9. An occasional year or two of fallow will aid in bringing the soil into better physical condition; will help in controlling such weeds as cat-tails, joint grass and spike rush; and will probably result in some increase in the yield of rice.

10. The minimum water temperature during the growing season is always somewhat higher than the minimum air temperature. From these studies the conclusion may be drawn that from the standpoint of "warming up the soil" there is nothing to be gained by withdrawing the water for a few days.

11. Studies carried on in 1924 and 1925 show that under the method of continuous submergence the net duty of water for rice should not amount to more than 5 acre-feet to the acre on the clay, clay adobe or adobe soils. On the loam soils the net duty may amount to as much as 8 acre-feet to the acre.

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